CLAIMS

1. A projection lens for magnifying and projecting an optical image formed on a spatial light modulator onto a screen, comprising:

a front lens group and a rear lens group that are arranged in this order from the screen side toward an image plane side,

wherein the rear lens group has an aperture stop that is eccentric with respect to an optical axis common to the front lens group and the rear lens group, and

focus adjustment is performed by moving the rear lens group in a direction of the optical axis without rotating the rear lens group.

2. The projection lens according to claim 1, wherein magnification adjustment is performed by moving the front lens group in the direction of the optical axis.

3. The projection lens according to claim 1, further comprising an auxiliary lens group between the rear lens group and the image plane.

4. The projection lens according claim 1, further comprising an optical path bending means between the front lens group and the rear lens group.

5. The projection lens according to claim 4, wherein the aperture stop is eccentrically displaced in a direction parallel to a plane containing the optical axes upstream and downstream of the optical path bending means.

6. The projection lens according to claim 4, wherein the aperture stop is eccentrically displaced in a direction perpendicular to a plane containing the optical axes upstream and downstream of the optical path bending means.

7. The projection lens according to claim 4, wherein when an angle between the optical axes upstream and downstream of the optical path bending means is θ, the following relationship is satisfied:

$$45° \leq \theta \leq 90° \qquad (13)$$

8. The projection lens according to claim 1, wherein the aperture stop has an opening having a substantially elliptical shape.

9. The projection lens according to claim 8, wherein when an amount of eccentricity of the aperture stop is D1 and an effective aperture radius in a position of the aperture stop is D2, the following condition is satisfied:

$$D1/D2 < 0.5 \qquad (12)$$

10. The projection lens according to claim 1, wherein an effective display area of the spatial light modulator has a rectangular shape having a long axis and a short axis, and the aperture stop is eccentrically displaced in a direction along the long axis or a direction along the short axis.

11. The projection lens according to claim 3,

wherein the front lens group comprises a first lens group having a negative power,

the rear lens group comprises a second lens group having a positive power and a third lens group having a positive power that are arranged in this order from the screen side,

the auxiliary lens group comprises a fourth lens group having a positive power, and

when an axial air gap between the first lens group and the second lens group is t12, an axial air gap between the third lens group and the

fourth lens group is t34, and a focal length of the entire system is f, the following conditions are satisfied:

$$6.2 < t12/f < 10.5 \quad (1)$$

$$2.7 < t34/f < 4.4 \quad (2)$$

12. The projection lens according to claim 11, wherein the aperture stop is disposed between the second lens group and the third lens group.

13. The projection lens according to claim 11,

wherein the first lens group comprises a negative meniscus lens whose convex surface faces the screen side and at least one surface of which is aspherical, and a negative lens that are arranged in this order from the screen side,

the second lens group comprises a positive lens, a cemented lens of a negative lens and a positive lens, and a positive meniscus lens whose convex surface faces the screen side that are arranged in this order from the screen side,

the third lens group comprises a negative meniscus lens whose convex surface faces the screen side, a positive lens, a cemented lens of a positive lens and a negative lens, a positive lens, and a positive lens that are arranged in this order from the screen side, and

the fourth lens group comprises a single positive lens.

14. The projection lens according to claim 11,

wherein the first lens group comprises a negative meniscus lens whose convex surface faces the screen side and at least one surface of which is aspherical, and a negative lens that are arranged in this order from the screen side,

the second lens group comprises a positive lens, a negative meniscus

lens whose convex surface faces the screen side, and a positive meniscus lens whose convex surface faces the screen side that are arranged in this order from the screen side,

the third lens group comprises a first cemented lens of a negative lens and a positive lens, a second cemented lens of a negative lens and a positive lens, and a positive lens that are arranged in this order from the screen side, and

the fourth lens group comprises a single positive lens.

15. The projection lens according to any one of claims 11 to 14, wherein a lens that is disposed in a position closest to the screen in the first lens group is an aspherical lens.

16. The projection lens according to claim 3 or 11, wherein the auxiliary lens group comprises a single plano-convex lens whose convex surface faces the screen side.

17. The projection lens according to any one of claims 11 to 14, wherein a lens that is disposed in a position closest to the spatial light modulator in the third lens group is made of an anomalous dispersion glass.

18. The projection lens according to any one of claims 11 to 14, wherein when an axial air gap between the fourth lens group and the image plane is d, the following conditions are satisfied:

$$1.6 < t34/d < 2.6 \quad (3)$$

$$4.2 < (t34 + d)/f < 6.0 \quad (4)$$

19. The projection lens according to any one of claims 11 to 14, wherein when a focal length of the first lens group is f1, a focal length of the second

lens group is f2, and a focal length of the third lens group is f3, the following conditions are satisfied:

$$-2.9 < f1/f < -2.1 \quad (5)$$

$$7.3 < f2/f < 14.5 \quad (6)$$

$$5.7 < f3/f < 7.5 \quad (7)$$

20. The projection lens according to claim 4, wherein the optical path bending means is a dielectric multilayer mirror.

21. The projection lens according to claim 13, wherein when an Abbe number and a refractive index of the positive lens constituting the cemented lens included in the second lens group are respectively $\nu 2p$ and n2p, and an Abbe number and a refractive index of the negative lens constituting the cemented lens included in the second lens group are respectively $\nu 2n$ and n2n, the following conditions are satisfied:

$$\nu 2p < \nu 2n \quad (8)$$

$$n2p < n2n \quad (9)$$

22. The projection lens according to claim 13 or 14, wherein when an Abbe number and a refractive index of the positive lens constituting the cemented lens included in the third lens group are respectively $\nu 3p$ and n3p, and an Abbe number and a refractive index of the negative lens constituting the cemented lens included in the third lens group are respectively $\nu 3n$ and n3n, the following conditions are satisfied:

$$\nu 3p > \nu 3n \quad (10)$$

$$n3p < n3n \quad (11)$$

23. A projection display apparatus, comprising:

a spatial light modulator for forming an optical image according to a video signal,

an illuminating means for illuminating the spatial light modulator, and

a projection lens for projecting the optical image formed on the spatial light modulator onto a screen,

wherein the projection lens according to any one of claims 1 to 22 is used as the projection lens.

24. The projection display apparatus according to claim 23, wherein the spatial light modulator is a DMD (Digital Micro-Mirror Device) comprising a two-dimensional array of a plurality of microscopic mirrors.

25. The projection display apparatus according to claim 23, further comprising a field stop on the screen side of the projection lens.

26. The projection display apparatus according to claim 23, wherein the illuminating means forms an illumination light that is switched between three primary colors, red (R), green (G), and blue (B), of light with time, and the spatial light modulator displays the optical images corresponding to the three primary colors of light while switching the optical images with time.

27. A rear projection display apparatus, comprising:

a projection display apparatus, and

a transmission-type screen for displaying an image projected from the projection display apparatus,

wherein the projection display apparatus according to any one of claims 23 to 26 is used as the projection display apparatus.

28. The rear projection display apparatus according to claim 27, further comprising a reflecting means for bending an optical path that is disposed between the projection display apparatus and the transmission-type screen.